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Comparability of Data obtained from Farmers and Surrogate Respondents on Use of Agricultural Pesticides

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Information from surrogates is increasingly being used in case-control studies to evaluate cancer risks from pesticides; however, little is known about the quality of this type of information. To address this concern, the authors compared interview data collected in 1987 from 95 male Iowa farmers and their wives or other surrogates on the use of specific agricultural pesticides. Agreement between direct and surrogate interviews was excellent (83–100%) for responses to dichotomous (yes/no) questions regarding past agricultural use of specific pesticides. Although there were more discrepancies for detailed questions (e.g., the number of days per year on which each pesticide was handled), responses from spouses appear to be adequate for epidemiologic studies of pesticides and cancer. *Am J Epidemiol* 1991;134:348–55.

agriculture; epidemiologic methods; interviews; pesticides; questionnaires

Case-control studies of rapidly fatal diseases must often rely on information obtained from an informant other than the subject (1). Although several investigators have evaluated the ability of surrogates to report smoking and dietary habits (2–9), few studies have assessed the accuracy of occupational histories obtained from a spouse (7–11). None, to our knowledge, has reported on the comparability of data collected from a spouse or other surrogate regarding exposures and practices specific to farmers. Case-control studies that include surrogate respondents are increasingly being used to evaluate cancer risks from the agricultural use of pesticides (12), and data on the comparability of such information are needed.

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Abbreviations: DDT, dichlorodiphenyltrichloroethane; 2,4-D, 2,4-dichlorophenoxyacetic acid.

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MATERIALS AND METHODS

Interviews

In 1987, as an adjunct to a case-control study of leukemia and non-Hodgkin's lymphoma in Iowa (13), we designed a methodologic study to collect information on the agricultural use of specific pesticides from a sample of 95 male farmers without leukemia or non-Hodgkin's lymphoma and their wives or other surrogates. Farmers and their surrogates were informed about the comparability study and were asked to participate by completing separate 10-minute telephone interviews. Farmers without spouses provided the name of a relative or friend who was knowledgeable about their farming activities. The interview sought information on the number of days per year on which specific pesticides had been handled by the farmer. This was asked with regard to two different time periods (before and after 1960) to take into account the historic changes in the type(s) and amount(s) of pesticides used and to note differences in the frequencies of pesticide use reported by subjects and spouses by time period. Each pair of respondents was asked only about pesticides that the farmer in an earlier survey (13) had reported ever using on his farm, even though he might not have handled them himself. The interview also collected information on the total number of days per year on which the farmer handled all herbicides or all insecticides regardless of time period (including those not specifically mentioned by the interviewer) and on when the farmer usually changed into clean work clothes (i.e., immediately after handling pesticides, at the end of the workday, or the following day).

Statistical analyses

To compare continuous data between farmer and surrogate interviews, we calculated group mean values (and standard deviations), Pearson correlation coefficients, and the mean of the differences between pairs of measurements (and its standard error). A paired-comparisons t test was used to test whether or not the mean difference was significantly different from zero. Continuous data were grouped into categories (e.g., 1–4, 5–9, and ≥10 days/year) consistent with those used to evaluate risk from pesticides in many epidemiologic studies. The overall proportion of exact agreement was used to compare dichotomous and categoric data. Comparisons of days per year of pesticide use are presented here only for those pesticides for which 20 or more farmer/spouse pairs gave quantitative responses.

Several hypothetic true distributions were generated using the frequency distributions of farmer respondents for three pesticides with different degrees of agreement: 2,4-dichlorophenoxyacetic acid (2,4-D), aldrin, and dichlorodiphenyltrichloroethane (DDT). For instance, for 2,4-D, there were 10 farmers in the nonexposed category, 31 in the low-frequency category, and 12 in the high-frequency category. These subjects were distributed in such a way that observed odds ratios would show positive and inverse trends with three frequency of pesticide use categories (1.00, 1.27, and 3.00 for the positive trend and 1.00, 0.62, and 0.33 for the inverse trend). Misclassification matrices were derived from comparison between farmer and spouse respondents, assuming that different responses from spouses resulted in misclassification. Conditional probabilities of each cell were calculated from the misclassification matrices between farmer and spouse respondents. For example, in the first misclassification matrix, out of 31 farmers in the low frequency of 2,4-D use category, 25 were correctly classified by their spouses as being in the low-frequency category, creating a conditional probability for correctly classifying the low-frequency category equal to 0.81 ($p = 25/31$); one was misclassified by his spouse as nonexposed, with a conditional probability equal to 0.03 ($p = 1/31$); and five were misclassified by their spouses into the high-frequency category, with a probability equal to 0.16 ($p = 5/31$). Using these exposure misclassification matrices for each pesticide, we calculated distorted observed odds ratios from several hypothetic dose-response trends: a positive trend with a maximum odds ratio of 3.00; no trend; and a negative trend with a minimum odds ratio of 0.33. Effects on risk estimates were measured by comparison of odds ratios, chi-square tests for trend, and p values for the trend tests from surrogate responses with those responses from the farmers themselves.

RESULTS

The wife was the surrogate respondent for most of the subjects (82.1 percent), while a child (11.6 percent), a sibling (4.2 percent), or a neighbor or friend (2.2 percent) provided responses for the remaining subjects. The ages of the farmers ranged from 29 years to 87 years (median = 60 years).

For each pesticide, table 1 shows the number of farmers and surrogates who reported that the subject had handled the pesticide and the overall percentage of exact agreement among farmer/spouse and farmer/other surrogate pairs for whether or not the farmer had handled the pesticide. Also

TABLE 1. Comparison of farmers' responses with those of their spouses or other surrogates concerning the farmer's use of specific pesticides before and after 1960, Iowa, 1987

Pesticide	Before/ after 1960	Respondent type	Handled		% exact agreement*	% who did not know no. of days handled
			No	Yes		
Alachlor	Before	Farmer	40	1		0
		Spouse	31	1	100.0	0
		Other	9	0	100.0	
	After	Farmer	2	41		4.9
		Spouse	2	31	100.0	19.3
		Other	1	9	90.0	22.2
Aldrin	Before	Farmer	26	19		5.3
		Spouse	20	17	100.0	0
		Other	6	2	100.0	50.0
	After	Farmer	8	40		0
		Spouse	7	32	100.0	6.3
		Other	1	8	100.0	37.5
Atrazine	Before	Farmer	40	5		0
		Spouse	34	4	100.0	0
		Other	6	1	100.0	0
	After	Farmer	2	42		7.1
		Spouse	1	36	100.0	8.3
		Other	1	6	100.0	0
Cyanazine	Before	Farmer	27	1		0
		Spouse	22	1	100.0	0
		Other	5	0	100.0	
	After	Farmer	1	31		6.5
		Spouse	1	25	100.0	12.0
		Other	1	5	83.3	20.0
DDT†	Before	Farmer	5	37		5.4
		Spouse	5	28	97.0	10.7
		Other	2	7	88.9	71.4
	After	Farmer	22	17		0
		Spouse	17	14	100.0	0
		Other	5	3	100.0	66.7
Trifluralin	Before	Farmer	41	3		33.3
		Spouse	34	3	100.0	0
		Other	7	0	100.0	
	After	Farmer	1	42		16.7
		Spouse	1	34	100.0	11.8
		Other	0	8	100.0	25.0
2,4-D†	Before	Farmer	38	34		2.9
		Spouse	29	31	96.7	10.0
		Other	7	5	100.0	0
	After	Farmer	11	63		6.6
		Spouse	9	52	95.1	7.7
		Other	1	12	100.0	16.7

* Agreement on whether or not the farmer handled the pesticide during the specified time period.
† DDT, dichlorodiphenyltrichloroethane; 2,4-D, 2,4-dichlorophenoxyacetic acid.

shown are the percentages of respondents who did not know the number of days per year on which the pesticide was handled. Agreement for ever use of specific pesticides was excellent for both the farmer/spouse pairs and the smaller number of farmer/other surrogate pairs, ranging from 95 percent to 100 percent and 83 percent to 100 percent, respectively. For example, of the 33 farmer/spouse pairs asked about use of alachlor after 1960, the concordance was 100 percent, with use of the pesticide reported by 31 pairs and non-use by two pairs. Similarly, of the 10 farmer/other pairs, nine pairs (90 percent) reported use of the pesticide, and for the remaining pair, use was reported by the farmer but not by his surrogate. Agreement appeared to be equally good for the earlier time period (before 1960) and the later time period (after 1960). Compared with farmers and spouses, the other surrogates more often gave a response of "don't know" when asked to quantify the number of days per year on which a specific pesticide was handled.

Table 2 presents farmer/spouse pair agreements on the number of days per year on which specific pesticides and classes of pesticides were handled by the farmer. For specific pesticides handled after 1960, responses by the farmer and his wife were significantly correlated, and the mean numbers and ranges of days of use were similar. The percentage of agreement in categories (1–4, 5–9, and ≥10 days/year) ranged from 66.7 percent to 52.0 percent. The percentage of agreement for the two pesticides used before 1960 (DDT and 2,4-D) was lower: 30 percent and 48 percent, respectively. The correlation coefficients for the actual numbers of days of use per year were smaller (0.23 for DDT and 0.30 for 2,4-D before 1960) than for the other pesticides, and the differences in the means and ranges were greater. The mean number of days per year on which all herbicides and all insecticides were used was substantially greater when it was reported by farmers than when it was reported by spouses. The mean of the differences between the responses of farmers and their spouses for all insecticides—13.4 days per year—was significantly different from zero. Agreement based on both the correlation coefficient and the percentage of agreement in categories, however, was lower for all herbicides than for all insecticides.

Percentage of agreement was high (92 percent) for the 77 farmer/spouse pairs who reported when the subject changed clothes after handling pesticides. For over 86 percent of the pairs, both reported that clothes were changed on the same day. Changing clothes immediately after pesticide use was reported by 9 percent of the farmers and 10 percent of the spouses. The percentage of "don't know" responses was small—3 percent and 1 percent for the farmers and their spouses, respectively. Percentage of agreement for farmer/other surrogate respondents was also high (87 percent). Changing clothes on the same day was the most common response; however, two farmers reported changing clothes immediately after pesticide use, and one surrogate reported

TABLE 2. Comparison of farmers' responses with their spouses' responses concerning the farmer's usual frequency of use of herbicides and insecticides before and after 1960, Iowa, 1987

Pesticide	Before/after 1960	No. of pairs†	No. of days/year of use: Farmer, Mean ± SD‡	Farmer, Range	Spouse, Mean ± SD	Spouse, Range	Mean of differences ± SE‡	Pearson correlation coefficient	% exact agreement in categories§
Alachlor	After	25	7.8 ± 5.5	2–25	6.7 ± 5.9	1–30	1.0 ± 0.7	0.80***	52.0
Aldrin	After	30	7.4 ± 5.0	1–21	6.2 ± 4.0	1–20	1.3 ± 0.7	0.63***	66.7
Atrazine	After	30	6.3 ± 5.8	1–25	6.0 ± 5.4	1–30	0.3 ± 0.7	0.78***	60.0
Cyanazine	After	21	5.5 ± 4.8	1–17	6.0 ± 4.3	1–20	−0.6 ± 0.8	0.66**	57.1
DDT‡	Before	23	13.5 ± 20.2	1–100	10.5 ± 11.7	2–60	3.0 ± 4.4	0.23	30.4
Trifluralin	After	27	6.7 ± 5.5	1–25	6.9 ± 6.4	1–30	−0.2 ± 0.7	0.84***	63.0
2,4-D‡	Before	26	12.5 ± 17.6	1–90	8.5 ± 7.9	2–30	4.0 ± 3.3	0.30	48.4
2,4-D	After	45	7.9 ± 6.3	1–30	7.0 ± 6.7	1–30	0.9 ± 0.6	0.78***	55.6
All herbicides		21	10.9 ± 19.2	2–90	6.3 ± 4.8	1–20	4.6 ± 4.0	0.31	52.4
All insecticides		25	49.2 ± 37.3	1–120	35.8 ± 33.1	1–120	13.4 ± 6.4*	0.58**	68.0

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

† Includes only the farmer/spouse pairs for which both members gave quantitative responses.

‡ SD, standard deviation; SE, standard error; DDT, dichlorodiphenyltrichloroethane; 2,4-D, 2,4-dichlorophenoxyacetic acid.

§ Categories for specific pesticides and all herbicides were 1–4, 5–9, and ≥10 days per year. Categories for all insecticides were 1–15, 16–60, and ≥61 days per year.

TABLE 3. Exposure misclassification matrices for frequency of use of selected pesticides (days per year), by number of subjects and probability, Iowa, 1987*

Pesticide			No. of subjects				p			
			Spouse				*Spouse*			
			0	1–9	≥10	*Total*	0	1–9	≥10	*Total*
2,4-D†	*Self*	0:	8	2	0	10	0.80	0.20	0.00	1.00
		1–9:	1	25	5	31	0.03	0.81	0.16	1.00
		≥10:	0	7	5	12	0.00	0.58	0.42	1.00
Aldrin	*Self*	0:	7	0	0	7	1.00	0.00	0.00	1.00
		1–9:	0	18	2	20	0.00	0.90	0.10	1.00
		≥10:	0	6	4	10	0.00	0.60	0.40	1.00
DDT†	*Self*	0:	4	0	0	4	1.00	0.00	0.00	1.00
		1–9:	0	6	6	12	0.00	0.50	0.50	1.00
		≥10:	1	6	5	12	0.08	0.50	0.42	1.00

* Self-responses are assumed to be true.
† 2,4,-D, 2,4-dichlorophenoxyacetic acid; DDT, dichlorodiphenyltrichloroethane.

that the farmer waited until the next day. The percentage of "don't know" responses was zero for the farmers and 12 percent for the other surrogates.

Conditional probabilities are shown in misclassification matrices for three frequently used pesticides in table 3. There was no nonadjacent misclassification for 2,4-D and aldrin among spouse respondents. For DDT, one subject from the high-frequency category was misclassified as nonexposed, with a conditional probability of $p = 0.08$. For the low-frequency category, misclassification occurred mostly toward the high-frequency category. For all three pesticides, the most common misclassification was from the high-frequency category to the low-frequency category.

Table 4 presents the effects of actual misclassification (differences between farmer and spouse responses) on two hypothetic distributions (one positive and one negative) for the same three pesticides. For both the positive and the negative hypothetic dose-response trends, distorted risks at the low-frequency categories were biased away from the null, while risks at the high-frequency categories were biased toward the null. As expected, if there was no dose-response trend in the hypothetic distribution (i.e., odds ratio = 1.0 for all exposure categories), misclassification matrices did not distort risks or create a false trend (14) (data not presented). Overall, misclassification matrices for the three selected pesticides did not cause substantial changes in the risk patterns to influence the interpretations of the results.

DISCUSSION

The present study was designed to assess the comparability of responses by farmers and their surrogates to questions concerning pesticide exposures experienced by the farm-

TABLE 4. Effect of misclassification matrices on the true odds ratio (OR) for hypothetic distributions of exposure (days per year) to selected pesticides, Iowa, 1987

Pesticide and disease status	Exposure status					
	True distribution			Misclassified distribution		
	0	1–9	≥10	0	1–9	≥10
2,4-D*						
Cases	5	19	9	4.57	21.80	6.63
Controls	5	15	3	4.45	15.04	3.51
OR	1.00	1.27	3.00	1.00	1.41	1.84
Chi-square for trend		1.31			0.35	
p value		0.188			0.722	
Cases	5	13	3	4.39	13.40	3.21
Controls	5	21	9	4.63	23.44	6.93
OR	1.00	0.62	0.33	1.00	0.60	0.49
Chi-square for trend		−1.18			−0.59	
p value		0.239			0.551	
Aldrin						
Cases	3	11	7	3.00	14.10	3.90
Controls	4	9	3	4.00	9.90	2.10
OR	1.00	1.63	3.11	1.00	1.90	2.48
Chi-square for trend		1.12			0.79	
p value		0.262			0.43	
Cases	3	6	2	3.00	6.60	1.40
Controls	4	14	8	4.00	17.40	4.60
OR	1.00	0.57	0.33	1.00	0.51	0.41
Chi-square for trend		−0.96			−0.99	
p value		0.336			0.323	
DDT*						
Cases	2	7	9	2.72	8.00	7.28
Controls	2	5	3	2.24	4.00	3.76
OR	1.00	1.40	3.00	1.00	1.65	1.59
Chi-square for trend		1.07			0.01	
p value		0.286			0.981	
Cases	2	5	3	2.24	4.00	3.76
Controls	2	7	9	2.72	8.00	7.28
OR	1.00	0.71	0.33	1.00	0.61	0.63
Chi-square for trend		−1.07			−0.79	
p value		0.286			0.432	

* 2,4-D, 2,4-dichlorophenoxyacetic acid; DDT, dichlorodiphenyltrichloroethane.

ers. Similarly to studies which compared pairs of respondents for smoking habits (4–7, 9), we found excellent agreement for the dichotomous pesticide use variable (yes or no for handling of each pesticide) but more discrepancies for the number of days per year on which each pesticide was handled. In general, frequency of use of specific pesticides as reported by the wife was slightly less than that reported by the farmer himself.

The lower agreement seen for frequency of DDT and 2,4-D use before 1960 and all herbicide use regardless of time period is probably due to both the larger range of use reported by the farmers for these pesticides compared with pesticides used after 1960 and the smaller range of use reported by the wives compared with the farmers. The large difference in the mean number of days of reported use of all insecticides may reflect the spouse's slight underestimation of each of the commonly used pesticides or the inability to recall as completely as the farmer use of pesticides not specifically mentioned in the questionnaire. Failure of spouses to recall all pesticides used by the farmers resembles findings from comparability studies in which wives recalled fewer of their husbands' jobs and residences than did the husbands themselves (9, 10, 14). Although there were differences between farmer and surrogate respondents, the effects of these exposure differences on risk estimates were not dramatic. Exposure response trends were diluted but were not eliminated.

Agreement was high for a categoric measure of exposure: "How soon after using pesticides did the farmer change clothes?" This high agreement, however, was due largely to the majority of both farmer and surrogate respondents' choosing the category "at the end of the workday."

As has been reported in methodologic studies of other factors (15), "don't know" responses were highest for questions seeking the most detailed information, in this case the number of days per year on which each pesticide was handled. For all variables included in this study, the percentage of "don't know" responses was generally lowest for the farmers themselves and highest for surrogate respondents other than the spouse.

Unlike other studies where the wife's knowledge of specific (nonfarm) occupational exposures was generally poor (8, 9, 11), it appears that wives of farmers can recall some details of farming-related exposures such as use of specific pesticides. This may be because pesticides play a critically important role in the production and management of crops and animals and because farmers' wives are more likely to be engaged in business-related operations with their husbands than are women whose husbands are not self-employed. Even if the wife works entirely "in the home," her physical proximity to the work site may also contribute to her understanding of chemicals used on the farm.

One limitation of this study was that we included only pesticides that the farmer had reported ever using on his farm in our earlier survey. Thus, we were unable to evaluate whether a surrogate might report the use of a pesticide that was not reported by the farmer. In addition, recall may have been enhanced among all respondents because queries did not concern all pesticides, only those used most frequently. A further limitation was that the reliability of surrogate interviews for farmers who had died of cancer or some other disease was not assessed. Therefore, the degree of possible recall bias by the cases is not known.

Nevertheless, it is reassuring that wives or other close surrogates of living subjects can give accurate responses to yes/no questions regarding past use of specific agricultural pesticides. As long as any differential recall for surrogates of cases and controls is minimal, questions on pesticide use requiring detailed quantitative responses from spouses, while of lower quality, appear to be adequate for epidemiologic purposes, especially if asked with regard to specific pesticides and relatively recent time periods.

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